**Sequence of Questions and Answers**

Today, we are going to learn about the thermal expansion of gases and how this relates to pressure. We will use what we already know about kinetic molecular theory to help us figure out what is happening in our experiment.

In order to do that, let’s review a few concepts.

What are the 3 states of matter? *Solid, Liquid and Gas*

Can someone remind me how molecules are organized in a solid? Liquid? Gas? (I will draw the solid. Can I have a volunteer draw the liquid? Gas?)

Using ice as an example, what is one way that I could change ice from a solid to a liquid to a gas? *Increase the temperature*.

And what happens to the water molecules themselves when we heat them up? *They begin to move faster. There is more space between particles.*

We learned from kinetic molecular theory that as we increase the temperature, the speed of the movement of gas particles increases. So which of these states of matter has the most space between particles? (gas)

I have just one more question for you before we start our experiment. Does air have weight? How do you know if you can’t feel it? I will leave you to think about that as we do the demo.

Let’s do our experiment!

In this can, I have 15mL of water that is boiling. While I let it boil for a minute, I would like to get some of your predictions. What do you think will happen when I take this can and turn it upside down into this bowl full of cold water? *Take predictions and write them on the board.*

So, what happened? What did you see? *The can collapsed or the can was crushed.*

What was in the can to begin with? *Water and air.*

Who can remind me what happens to water when it is heated? *The molecules move faster and move farther apart from each other. You end up with water vapour, a gas.*

And so if the water molecules are expanding, what do you think happens to the air inside the can? *It gets pushed out.*

So, knowing what we now know about what happened to the water and the air, can someone explain why the can collapsed when I inverted it into the cold water? *The water vapour condensed leaving empty space inside the can. The pressure outside of the can was then greater than the pressure inside the can so it collapsed.*

We discussed earlier that atmospheric pressure is pushing down on us all the time. Why doesn't all that pressure crush us? *Remember that you have air* inside *your body too, that air balances out the pressure outside so you stay nice and firm and not squishy.*

What if I had let the can cool down before plunging it into the water? Would it have collapsed? *No.*

Why not? *Because there would have been time for air to enter the can so the pressure inside the can would have been the same as the pressure outside of the can.*

Let’s do the experiment one more time. (do experiment)

What if I had performed this very same experiment on the top of Mount Everest? What would you expect to happen in that environment and why? *The can would have probably collapsed slower or less because atmospheric pressure at high altitude is less than that at sea level. The water inside the can would have also taken longer to boil.*

Can anyone think of a modification that we could make to this experiment in order to achieve the same collapsing effect without inverting the can into a bowl of ice water? Let’s brainstorm some ideas. *Seal the mouth of the can and let it cool.*

Why would the can collapse if we sealed the opening and let the can cool? *It would collapse because as the can cools, the water vapour condenses. Since no air may enter the can, there will be empty space inside the can causing the pressure inside to be less than the atmospheric pressure outside of the can.*

Hmmm, very interesting. So we can see that there seems to be a connection between temperature of a gas and pressure. Remind me one more time what happened to the volume of the water vapour when it was heated*? It expanded/increased*. Interesting again, there also seems to be a connection between temperature and volume.

This leads us into our lesson today where we will learn about the gas laws and how they help us explain the relationships between the temperature, volume and pressure of a gas.

THE END. Questions?

**Rationale for demo/worksheet questions:**

* Review of changes of states of matter.
* Intro to kinetic molecular theory and gas laws.
* Practice making predictions based on prior knowledge.
* Practice making observations and connecting observations to scientific theory.
* Practice writing out a procedure for scientific problem solving.
* Making STSE connections.